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Indian Standard

ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF OVERHEAD POWER LINES AND HIGH VOLTAGE EQUIPMENT

PART 1 DESCRIPTION OF PHENOMENA

Section 4 Sparking Due to Bad Contacts

UDC 621·391·823 [621·396] : 621·315·1

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Indian Standard

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Indian Standard

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PART 1 DESCRIPTION OF PHENOMENA

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0. FOREWORD

0.1 This Indian Standard (Part 1/Sec 4) was adopted by the Bureau of Indian Standards on 31 July 1987, after the draft finalized by the Electromagnetic Compatibility Sectional Committee, had been approved by the Electronics and Telecommunication Division Council.

0.2 The purpose of the series of Part 1 of this standard is to discuss the physical phenomena involved in the generation of electromagnetic noise fields. This also includes the main properties of such fields and their numerical values.

0.3 The technical data given in these standards will be useful aid to overhead line designers and also to any one concerned with checking of electromagnetic noise performance of a line to ensure satisfactory protection of wanted electromagnetic signals.

0.3.1 The technical data should facilitate the use of the recommendations which will be given in Parts 2 and 3. These parts comprising of different sections are proposed to be issued as given below:

Part 1 Description of phenomena

Part 2 Methods of measurement and procedure of determining limits

Part 3 Code of practice for minimizing the generation of radio noise

0.4 This standard is proposed to be issued in the following sections which would clarify only one aspect over the electromagnetic interference due to overhead power lines and high voltage equipment:

Section 1 Radio noise from power lines

Section 2 Effect of corona from conductors

Section 3 Radio noise levels due to insulators, fittings and sub-station equipment (excluding bad contacts)

Section 4 Sparking due to bad contacts

Section 5 Special DC effects

0.5 This standard (Part 1) has been largely based on CISPR Publication 18-1 (First Edition-1982) 'Radio interference characteristics of overhead power lines and high voltage equipment, Part 1 Description of phenomena', issued by the International Special Committee on Radio Interference of the International Electrotechnical Commisson (IEC).

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part 1 / Sec 4) deals with radio noise generated by sparking due to bad contacts, which may cause interference to radio/TV reception.

1.2 The frequency range concerned is 0·15 to 300 MHz.

2. TERMINOLOGY

2.0 For the purpose of this standard, the definitions given in IS : 1885 (Part 36)-1972† shall apply.

3. PHYSICAL ASPECTS OF RADIO NOISE PHENOMENON

3.1 Sparking Due to Bad Contacts — Unbonded conducting parts of a power line or substation, or even such items as nearby metal fences or rain-water guttering, when in the strong electric field of high voltage power lines and associated equipment, can become electrically charged and the potential difference between adjacent conducting parts will increase even if both parts are floating, that is to say, they are not connected to a line conductor or to earth.

If the distance separating the conducting parts is small, the increasing field strength in the intervening space may reach the critical level and lead to a complete breakdown of the gap. Avalanche ionization initiates

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*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabularly: Part 36 Radio interference.

the development of an arc, gap discharge occurs, the potential difference across the gap then falls to a low level and the arc extinguishes. The whole sequence of events can be repeated when the parts become re-charged, as the space is once again electrically stressed and the next gap discharge takes place.

3.2 The repetition rate of this sequence depends on charging and discharging time constants of the circuit and the value of the surrounding electric field, as well as on the length of the gap. Individual sparks can occur at many hundreds to a few thousands of times per second. The repetition rate, is, however, at least one order of magnitude lower than the range of repetition rates of corona discharge.

The probability of a particular gap sparking over is, of course, greater around the peaks of the power frequency voltage. When the line voltage and consequently the field strength in the gap, exceeds a critical value, a train or burst of sparks is generated during each half-cycle.

3.3 The significant factor in the shape of the discharge pulse is its steep rise time and consequently a broad range of high frequencies is produced and emitted. A comparison between the frequency spectra of the radio noise field from corona and gap-type discharges at a particular distance from the line, is shown in Fig. 1. The emitted frequencies may extend to a few hundred megahartz. If the discharge process excites a fitting or component which is capable of oscillating at a particular frequency, due to its geometrical dimensions, energetic narrow-band radiation at this frequency may occur as the fitting or component acts as a tuned aerial. Therefore, gap-type discharges may cause interference to the reception of both amplitude modulated (am) radio signals and the vision signals of television. By contrast, frequency modulated (fm) radio in the very high frequency (vhf) band, and the audio signals of television are less likely to be affected by this type of interference.

3.4 Propagation along the line with the associated electric and magnetic fields, and radiation are the routes by which the disturbing radio frequency reach the receiving aerial. It has been observed, in practice, that noise at frequencies corresponding to the long and medium wave band propagate some tens of kilometres along the line. At television and fm radio frequencies, the propagation along the line is less important than the radiation from the source. Line geometry, resistance of the underlying ground and the frequency are of major importance to propagation. For the higher frequencies, the attenuation along the greater and the distance cf propagation is shorter.

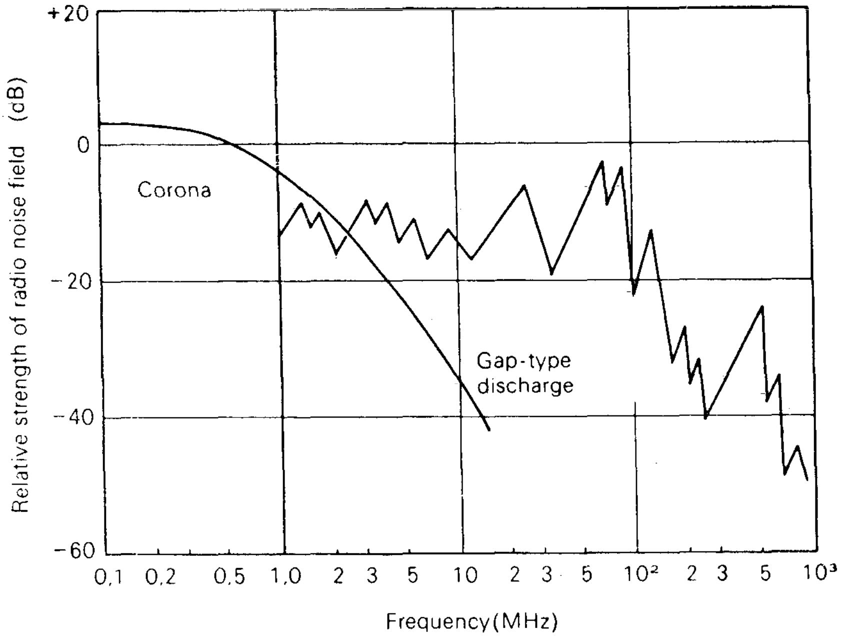

FIG. 1 EXAMPLE OF RELATIVE STRENGTH OF RADIO NOISE FIELD AS A FUNCTION OF FREQUENCY

3.5 Significant levels of the radio noise field are normally confined to the immediate vicinity of the line, possibly reaching out to a few hundred metres on either side. If, however, a reasonant condition occurs in a fitting or component, a narrow band of radiation may be measured at distances of up to a few kilometres. A curve showing a typical relationship between field strength and distance is shown in Fig. 2. The fluctuations are the result of the interaction of the direct wave with the ground-reflected wave.

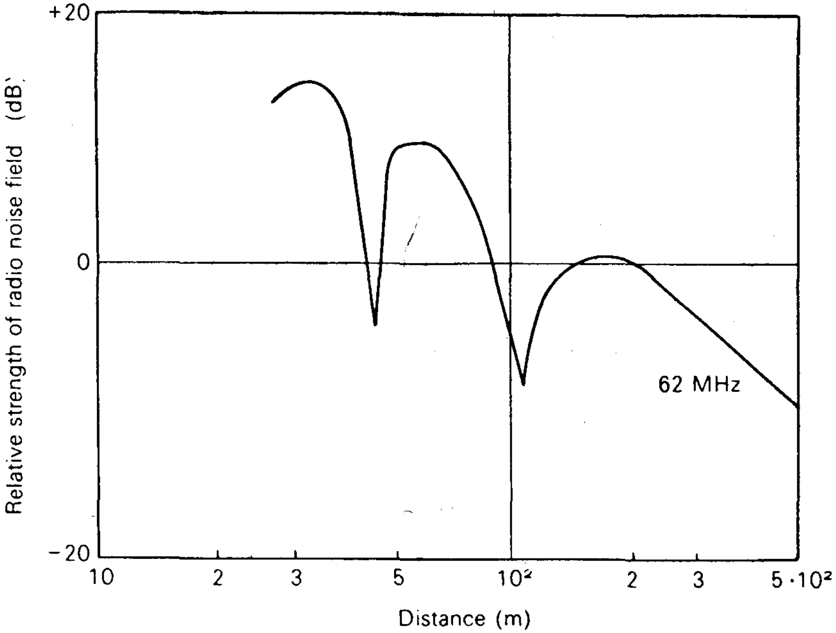

FIG. 2 EXAMPLE OF RELATIVE STRENGTH OF RADIO NOISE FIELD AS A FUNCTION OF THE DISTANCE FROM THE LINE

4. EXAMPLES OF GAP SOURCES

4.1 Gap sources on overhead lines may be due to lightly weighted cap and pin insulators, where the weight of the insulator is insufficient to prevent the metal contact surfaces from oxidizing, or with corroded metal parts or faulty joints. In the case of porcelain string insulator units, it has been found that sparks can be produced by discharges in small voids in the porcelain. Broken insulators, paint layers and even objects not forming part of a transmission line, such as nearby unbonded metal fences or gutters, may give rise to gap discharges.

4.2 Where wood poles are used for power lines, sparking may occur between items of metal fittings which can lead to severe interference to television reception. This usually occurs due to the shrinking or swelling of the wood with variations in humidity. As the wood shrinks, nuts and bolts used to hold the cross-arms in place, or to fasten insulator pins to the pole or cross-arm, can become slightly loose. If any corrosion is present between the nut and bolt, or the washer if one is used, an imperfect contact results and sparking takes place.

Another source of television interference from wood-pole lines can arise from the staples used to fasten the earth wire to the pole. As there are potential differences between sections of the pole, the staples may spark over to the earth wire, particularly if there is any corrosion between them.

4.3 Finally, the contact between a pin-type insulator and phase conductor can be a source of sparking at the tie-wire, where the conductor rests in the top groove, or at the stirrups in the side groove. The problem is the small, highly stressed, pockets of air between the conductor and the insulator that may spark over.

Care must be taken both during the erection of the line to ensure good workmanship throughout and, in subsequent maintenance to ensure that any defects caused, for example, by vandalism, are found and the necessary remedial action taken. Special attention should be given to design and maintenance of equipment to ensure the durability and adequacy of contacts at, for example, air-break isolating switches, the flexible connections provided in the design of such switches, fuse-mounts and line taps.

4.4 Gap discharges are strongly influenced by weather. It is only in dry weather that a small gap between, for example, two conducting parts provides insulation which can break down. In wet weather, the gap may be bridged with water thereby establishing a conducting path. Therefore, interference caused by gap discharges is a phenomenon that is normally associated with fair weather and it is usually absent in wet weather, consequently, this type of interference is often referred to as dry noise.